CLAIMS

What we claim is:

1. A thin-film electrochemical cell structure, comprising:

a cathode sheet layer comprising a series of discontinuous cathode sheets, each of the cathode sheets comprising:

a cathode layer; and

a current collector layer having a first surface contacting a first surface of the cathode layer;

a gap defined between adjacent ones of the cathode sheets; and

a solid electrolyte layer contacting a second surface of the cathode layer and extending across the gaps defined between the adjacent cathode sheets.

2. The structure of claim 1, further comprising an electrical insulator layer contacting a second surface of the current collector layer.

3. The structure of claim 2, wherein the electrical insulator layer extends across the gaps defined between the adjacent cathode sheets.

4. The structure of claim 1, wherein the electrolyte layer comprises a solid polymer electrolyte layer.

5. The structure of claim 1, wherein the gap defined between adjacent cathode sheets ranges between about 0.015 inches and about 0.4 inches.

6. The structure of claim 1, wherein a width of the cathode sheets ranges between about 0.75 inches and about 24 inches.

7. The structure of claim 1, wherein a length of the cathode sheets ranges between about 0.25 inches and about 24 inches.

8. The structure of claim 1, wherein the solid electrolyte layer encompasses a perimeter of the cathode layer of each of the cathode sheets.

9. The structure of claim 1, wherein the solid electrolyte layer comprises a first edge and a second edge, and each of the cathode sheets comprises a first edge and a second edge, the first and second edges of the solid electrolyte layer extending beyond the first and second edges of each cathode sheet by between about 0.04 inches and about 0.31 inches.

10. The structure of claim 1, wherein the current collector layer comprises a first edge and a second edge, and the cathode layer comprises a first edge and a second edge, the first edge of the current collector layer extending beyond the first edge of the cathode layer.

11. The structure of claim 10, wherein the first edge of the current collector layer extends beyond the first edge of the cathode layer by between about 0.08 inches and about 0.51 inches.

12. The structure of claim 10, wherein the second edge of the current collector layer extends beyond the second edge of the cathode layer by between about 0.0 inches and about 0.315 inches.

13. The structure of claim 1, wherein the series of discontinuous cathode sheets is arranged in a plurality of rows to define a matrix of the discontinuous cathode sheets, and a gap defined between adjacent rows ranges between 0 inches and about 0.63 inches.

14. The structure of claim 1, wherein the solid electrolyte layer comprises a first edge, the current collector layer comprises a first edge, and the cathode layer comprises a first edge, the first edge of the current collector layer extending beyond both the first edge of the cathode layer and the first edge of the solid electrolyte layer.

15. The structure of claim 14, wherein the first edge of the current collector layer extends beyond the first edge of the solid electrolyte layer by between about 0.04 inches and about 0.35 inches.

16. The structure of claim 14, wherein the first edge of the solid electrolyte layer extends beyond the first edge of the cathode layer.

17. The structure of claim 14, wherein a second edge of the solid electrolyte layer extends beyond a second edge of the cathode and current collector layers, respectively.

18. The structure of claim 1, wherein the cathode layer comprises a cathode active material, an electrically conductive material, an ionically conducting polymer, and an electrolyte salt.

19. The structure of claim 1, wherein the cathode layer comprises a vanadium oxide material or a lithiated vanadium oxide material.

20. The structure of claim 1, wherein the cathode layer comprises a cathode active material selected from the group consisting of $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, $Li[M(1-x)Mnx]O_2$ where $0<x<1$ and M represents one or more metal elements, polyacetylene, polypyrrole, polyaniline, polythiophene, MoS_2, MnO_2, TiS_2, $NbSe_3$, $CuCl_2$, a

fluorinated carbon, Ag_2CrO_4, FeS_2, CuO, $Cu_4O(PO_4)_2$, sulfur, and polysulfide.

21. The structure of 1, wherein the solid electrolyte layer comprises a random polyether copolymer of ethylene oxide and an ether oxide selected from the group consisting of propylene oxide, butylene oxide, and alkylglycidylether.

22. The structure of 1, wherein the solid electrolyte layer comprises a crosslinked solid ionically conductive polymer comprising urethane groups, urea groups, thiocarbamate groups, or combinations thereof and inorganic particles.

23. The structure of claim 1, wherein the solid electrolyte layer comprises a first surface and a second surface, the first surface of the solid electrolyte layer contacting the second surface of the cathode layer, the structure further comprising an anode layer contacting the second surface of the solid electrolyte layer.

24. The structure of claim 23, wherein the anode layer comprises lithium.

25. The structure of claim 23, further comprising an electrical insulator layer contacting a second surface of the current collector layer.

26. A thin-film electrochemical cell structure, comprising:

a cathode sheet layer comprising a series of discontinuous cathode sheets, each of the cathode sheets comprising:

a first cathode layer comprising a first surface and a second surface;

a second cathode layer comprising a first surface and a second surface; and

a current collector layer disposed between the respective first surfaces of the first and second cathode layers;

a gap defined between adjacent ones of the cathode sheets;

a first solid electrolyte layer contacting the second surface of the first cathode layer and extending across the gaps defined between the adjacent cathode sheets; and

a second solid electrolyte layer contacting the second surface of the second cathode layer and extending across the gaps defined between the adjacent cathode sheets.

27. The structure of claim 26, wherein the first and second electrolyte layers respectively comprise a solid polymer electrolyte layer.

28. The structure of claim 26, wherein the gap defined between adjacent cathode sheets ranges between about 0.015 inches and about 0.4 inches.

29. The structure of claim 26, wherein a width of the cathode sheets ranges between about 0.75 inches and about 24 inches.

30. The structure of claim 26, wherein a length of the cathode sheets ranges between about 0.25 inches and about 24 inches.

31. The structure of claim 26, wherein the first and second solid electrolyte layers respectively encompass a perimeter of the cathode layer of each of the cathode sheets.

32. The structure of claim 26, wherein the respective first and second solid electrolyte layers comprise a first edge and a second edge, and each of the cathode sheets comprises a first edge and a second edge, the first and second edges of the respective first and second solid

electrolyte layers extending beyond the first and second edges of each cathode sheet by between about 0.04 inches and about 0.31 inches.

33. The structure of claim 26, wherein the current collector layer comprises a first edge and a second edge, and the respective first and second cathode layers comprise a first edge and a second edge, the first edge of the current collector layer extending beyond the first edge of the respective first and second cathode layers.

34. The structure of claim 33, wherein the first edge of the current collector layer extends beyond the first edge of the respective first and second cathode layers by between about 0.08 inches and about 0.51 inches.

35. The structure of claim 33, wherein the second edge of the current collector layer extends beyond the second edge of the respective first and second cathode layers by between about 0.0 inches and about 0.315 inches.

36. The structure of claim 26, wherein the series of discontinuous cathode sheets is arranged in a plurality of rows to define a matrix of the discontinuous cathode sheets, and a gap defined between adjacent rows ranges between 0 inches and about 0.63 inches.

37. The structure of claim 26, wherein the respective first and second solid electrolyte layers comprise a first edge, the current collector layer comprises a first edge, and the respective first and second cathode layers comprise a first edge, the first edge of the current collector layer extending beyond both the first edge of the respective first and second cathode layers and the first edge of the respective first and second solid electrolyte layers.

38. The structure of claim 37, wherein the first edge of the current collector layer extends beyond the first edge of the respective first and second solid electrolyte layers by between about 0.04 inches and about 0.35 inches.

39. The structure of claim 37, wherein the first edge of the respective first and second solid electrolyte layers extends beyond the first edge of the respective first and second cathode layers.

40. The structure of claim 37, wherein a second edge of the respective first and second solid electrolyte layers extends beyond a respective second edge of the respective first and second cathode layers and current collector layers.

41. The structure of 26, wherein the respective first and second cathode layers comprise a cathode active material, an electrically conductive material, an ionically conducting polymer, and an electrolyte salt.

42. The structure of 26, wherein the respective first and second cathode layers comprise a vanadium oxide material or a lithiated vanadium oxide material.

43. The structure of 26, wherein the respective first and second cathode layers comprise a cathode active material selected from the group consisting of $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, $Li[M(1-x)Mnx]O_2$ where $0<x<1$ and M represents one or more metal elements, polyacetylene, polypyrrole, polyaniline, polythiophene, MoS_2, MnO_2, TiS_2, $NbSe_3$, $CuCl_2$, a fluorinated carbon, Ag_2CrO_4, FeS_2, CuO, $Cu_4O(PO_4)_2$, sulfur, and polysulfide.

44. The structure of 26, wherein the respective first and second solid electrolyte layers comprise a random polyether copolymer of ethylene oxide and an ether oxide selected from the group consisting of proplylene oxide, butylene oxide, and alkylglycidylether.

45. The structure of 26, wherein the respective first and second solid electrolyte layers comprise a crosslinked solid ionically conductive polymer comprising urethane groups, urea groups, thiocarbamate groups, or combinations thereof and inorganic particles.

46. The structure of claim 26, wherein the second solid electrolyte layer comprises a first surface and a second surface, the first surface of the solid electrolyte layer contacting the second surface of the second cathode layer, the structure further comprising an anode layer contacting the second surface of the second solid electrolyte layer.

47. The structure of claim 46, wherein the anode layer comprises lithium.

48. The structure of claim 46, further comprising a releasable separator layer contacting the second surface of the first electrolyte layer.

49. A method of producing a series of thin-film electrochemical cell structures, comprising:

cutting a web (cathode web), comprising a cathode layered structure, moving at a first speed into a series of cathode sheets;

moving a web (electrolyte web) of a solid electrolyte at a second speed equal to or greater than the first speed;

laminating each of the cathode sheets moving at the first speed with the electrolyte web moving at the second speed to produce a

first laminate structure having a space between adjacent cathode sheets; and

laminating a web (third web) of a material with the first laminate structure such that the cathode sheets are disposed between the electrolyte web and the third web.

50. The method of claim 49, wherein the material of the third web comprises a solid electrolyte.

51. The method of claim 49, wherein the material of the third web comprises an electrical insulator.

52. The method of claim 49, wherein cutting the cathode web comprises rotatably cutting the cathode web.

53. The method of claim 49, wherein laminating each of the cathode sheets comprises rotatably laminating each of the cathode sheets with the electrolyte web.

54. The method of claim 49, wherein laminating the third web of the material comprises rotatably laminating the third web of the material with the first laminate structure.

55. The method of claim 49, wherein cutting the cathode web comprises cutting a portion of the cathode web and removing excess cathode web.

56. The method of claim 55, wherein the space between adjacent cathode sheets is a function of one or both of a size and shape of the removed excess cathode web.

57. The method of claim 49, wherein each of the cathode sheets is defined by a length and cutting the cathode web comprises cutting the cathode web with a rotary die, the length of each cathode sheet being a function of the first speed of cathode web movement relative to the second speed of the rotary die.

58. The method of claim 49, wherein each of the cathode sheets is defined by a length and cutting the cathode web comprises cutting the cathode web with at least one rotating die blade separated by a circumferential blade spacing, the length of each cathode sheet being a function of the first speed of cathode web movement relative to the circumferential die blade spacing and the second speed of the rotating die blade.

59. The method of claim 49, wherein the space between adjacent cathode sheets is a function of the first speed of cathode web movement relative to the second speed of the electrolyte web.

60. The method of claim 49, wherein cutting the cathode web comprises cutting the cathode web with at least one rotating die blade separated by a circumferential blade spacing (D), further wherein the space (S) between adjacent cathode sheets is a function of the first speed (W1) of cathode web movement relative to the circumferential die blade spacing (D) and the second speed (W2) of the rotating die blade.

61. The method of claim 60, wherein the space (S) between adjacent cathode sheets is characterized by an equation $S = D((W2/W1) - 1)$.

62. The method of claim 49, wherein the space between adjacent cathode sheets ranges between about 0.015 inches and about 0.4 inches.

63. The method of claim 49, wherein laminating each of the cathode sheets with the electrolyte web further comprises laminating each of the cathode sheets with the electrolyte web such that a portion of a current collector of each cathode sheet extends beyond at least one edge of the electrolyte web.

64. The method of claim 63, wherein the portion of the current collector of each cathode sheet extends beyond the at least one edge of the electrolyte web by between about 0.04 inches and about 0.35 inches.

65. The method of claim 49, wherein the cathode web comprises a plurality of down-web directed rows of the cathode layered structure, and cutting the cathode web comprises cutting the cathode web in a cross-web direction to produce a matrix of the cathode sheets.

66. The method of claim 49, the method further comprising laminating a web (lithium web) of lithium material with the electrolyte web.

67. The method of claim 66, further comprising cutting through the lithium web, third web, and electrolyte web at respective locations in alignment with the space between adjacent cathode sheets.

68. The method of claim 67, wherein cutting through the respective lithium, third, and electrolyte webs comprises rotatably cutting through the respective lithium, third, and electrolyte webs.

69. The method of claim 67, wherein the electrolyte web comprises a carrier web, further wherein cutting through the respective lithium, third, and electrolyte webs comprises rotatably cutting through

the respective lithium, third, and electrolyte webs but not cutting entirely through the carrier web.

70. An apparatus for producing a series of thin-film electrochemical cell structures, comprising:

a first feed station that feeds a web (cathode web), comprising a cathode layered structure, at a first speed;

a rotary cutting station that receives the cathode web from the first feed station and rotatably cuts the cathode web, moving at the first speed, into a series of cathode sheets;

a second feed station that feeds an electrolyte web at a second speed greater than or equal to the first speed;

a first rotary lamination station that receives the electrolyte web and the cathode web, the first rotary lamination station rotatably laminating each of the cathode sheets moving at the first speed with the electrolyte web moving at the second speed to produce a first laminate structure having a space between adjacent cathode sheets;

a third feed station that feeds a web (third web) of a material; and

a second rotary lamination station that receives the third web and the first laminate structure, the second rotary lamination station rotatably laminating the third web with the first laminate structure such that the cathode sheets are disposed between the electrolyte web and the third web.

71. The apparatus of claim 70, wherein the material of the third web comprises an electrical insulator.

72. The apparatus of claim 70, wherein the material of the third web comprises a solid electrolyte.

73. The apparatus of claim 70, wherein the space between adjacent cathode sheets is a function of the first speed of cathode web movement relative to the second speed of the electrolyte web.

74. The apparatus of claim 70, wherein each of the cathode sheets is defined by a length and the rotary cutting station comprises a rotary die, the length of each cathode sheet being a function of the first speed of cathode web movement relative to the second speed of the rotary die.

75. The apparatus of claim 70, wherein the rotary cutting station comprises a rotary die, the rotary die comprising at least one rotary die blade separated by a circumferential blade spacing (D), further wherein the space (S) between adjacent cathode sheets is a function of the first speed (W1) of cathode web movement relative to the circumferential die blade spacing (D) and the second speed (W2) of the rotary die.

76. The apparatus of claim 75, wherein the space (S) between adjacent cathode sheets is characterized by an equation $S = D((W2/W1) - 1)$.

77. The apparatus of claim 70, wherein the space between adjacent cathode sheets ranges between about 0.015 inches and about 0.4 inches.

78. The apparatus of claim 70, wherein the cathode web comprises a plurality of down-web directed rows of the cathode layered structure, and the rotary cutting station cuts the cathode web in a cross-web direction to produce a matrix of the cathode sheets.

79. The apparatus of claim 78, wherein a space between adjacent rows of the cathode layered structure ranges between 0 inches and about 0.63 inches.

80. An apparatus for producing a series of thin-film electrochemical cell structures, comprising:

a first feed station that feeds a half-cell web at a first speed, the half-cell web comprising a cathode sheet layer comprising a series of spaced cathode sheets disposed between a solid electrolyte layer and a third layer, the solid electrolyte and third layers respectively extending across gaps defined between the spaced cathode sheets;

a second feed station that feeds a web (lithium web) of lithium material;

a rotary lamination station that receives the half-cell web and lithium web, the first rotary lamination station rotatably laminating the half-cell web with the lithium web to produce a unit cell structure; and

a cutting station that receives the unit cell structure, the cutting station cutting through the unit cell structure at respective locations in alignment with the gaps defined between the spaced cathode sheets to produce a cut unit cell structure.

81. The apparatus of claim 80, wherein the cutting station comprises a rotary die that rotatably cuts through the unit cell structure at the respective locations in alignment with the gaps defined between the spaced cathode sheets.

82. The apparatus of claim 80, wherein the electrolyte web comprises a carrier web, further wherein the cutting station cuts through the respective lithium, third, and electrolyte webs comprises rotatably cutting through the respective lithium, third, and electrolyte webs but does not cut entirely through the carrier web.

83. The apparatus of claim 80, wherein the space between adjacent cathode sheets ranges between about 0.015 inches and about 0.4 inches.

84. The apparatus of claim 80, wherein the cathode web comprises a plurality of down-web directed rows of the cathode layered structure, and the rotary cutting station cuts the cathode web in a cross-web direction to produce a matrix of the cathode sheets.

85. The apparatus of claim 84, wherein a space between adjacent rows of the cathode layered structure ranges between 0 inches and about 0.63 inches.